



Kristi Zakrzewski, P.E.  
MDEQ - Superfund Section  
Constitution Hall, 3rd Floor South  
525 West Allegan Street  
Lansing, MI 48909

Subject:

Willow Boulevard/A-Site Operable Unit Groundwater Monitoring Program  
Kalamazoo, Michigan

Dear Ms. Zakrzewski:

This letter has been prepared on behalf of Georgia-Pacific LLC (Georgia-Pacific), by ARCADIS to request concurrence from the Michigan Department of Environmental Quality (MDEQ) that, based on an evaluation carried out consistent with Michigan Act 451 Part 201 (Part 201) Rules, the groundwater-surface water interface (GSI) pathway for polychlorinated biphenyls (PCBs) between the Willow Boulevard/A-Site Operable Unit (WB/A-Site OU) and the Kalamazoo River (River) is *de minimis*. The information and data supporting this conclusion were presented at the October 22, 2012 meeting attended by the MDEQ, U.S. Environmental Protection Agency (USEPA), Georgia-Pacific, and ARCADIS. A subset of the material presented at the meeting is summarized here and attached for your reference.

**Demonstration of *de minimis* Effect on Kalamazoo River**

The evaluation of the nature of the contribution of PCBs from the WB/A-Site OU to the River included the consideration of several key factors – the chemical and physical properties of PCBs, the chemical and physical properties of paper-making residuals (residuals), groundwater flow and groundwater quality conditions at the WB/A-Site OU, as well as flow conditions in the River. Each of these factors was used in the estimation of PCB flux in groundwater between the residuals in the WB/A-Site OU and surface water in the River. This flux estimate was then compared to the PCB flux from River sediments to surface water to confirm that groundwater at the OU has a *de minimis* effect on PCB concentrations in the River.

Imagine the result

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ENVIRONMENT

Date:

December 14, 2012

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B0064581.0003.00672

*PCB Flux in Groundwater.* To estimate the potential PCB flux in groundwater from the WB/A-Site OU to the River, we used a model adapted from MDEQ Operational Memorandum RRD-5, Attachment 1. The conservative assumptions built into each model input parameter are listed below.

- Hydraulic conductivity of residuals =  $1.5 \times 10^{-3}$  centimeters per second (cm/sec), or 0.00005 feet per second (ft/sec)
- Hydraulic gradients between the OU and the River of 0.003 to 0.01 feet/foot – based on site-specific measurements
- River flow of 575 cubic feet per second (cfs) – this is the lowest mean monthly discharge rate in the area of the OU
- Average groundwater PCB concentration of 0.042 micrograms per liter (µg/L) – this value was calculated using actual detected concentrations and assuming PCBs are present at all non-detect monitoring points at a concentration of one-half of the detection limit

Using these conservative assumptions, the average annual groundwater PCB flux to the River is 0.0003 kilograms per year (kg/yr).

*PCB Flux in Sediments.* The PCB flux in groundwater was then compared to the flux of PCBs from sediments located adjacent to the WB/A-Site OU to River surface water. The modeled PCB flux from River sediments to surface water is calculated to be 0.05 kg/yr. The comparison indicates that the PCB flux from groundwater is negligible – less than 1% percent – relative to the calculated flux from River sediments, even when assuming the PCB concentrations in the sediments are at the MDEQ's default detection limit criterion.

*PCB Data.* The measured PCB concentration in surface water upstream of the WB/A-Site OU is approximately 0.001 µg/L. This is compared to the estimated average PCB concentration in the River attributable to groundwater from the WB/A-Site OU of 0.0000006 µg/L – an estimate based on two very conservative assumptions: 1) that PCBs are present at all wells that were non-detect for PCBs at

concentrations of one-half of the detection limit under conditions prior to construction of the Part 115 cover system, and 2) that the PCB concentrations (both measured and assumed) in groundwater are present at the point that groundwater discharges to the River. Adding the PCB concentration in venting groundwater to the PCB concentration in upstream surface water results in a final instream PCB concentration of 0.0010006 µg/L. The groundwater component is two to three orders of magnitude below the Rule 57 surface water quality criteria of 0.00012 µg/L (WV) and 0.000026 µg/L (HCV), and three orders of magnitude lower than the reporting limit of 0.001 µg/L.

*Additional Evidence.* The conclusion that there is a *de minimis* contribution from PCB flux in groundwater and the determination under Part 201 is further supported by monitoring data collected across the broader Superfund Site and the other landfill OUs.

- At Willow Boulevard, PCBs have never been detected in representative groundwater samples.
- At A-Site, PCBs were detected in half of the samples collected; however, none of the detections were above the relevant GSI criterion.
- At the King Highway Landfill OU, after eight years of data collection, the monitoring program was scaled back because PCBs were never detected at concentrations above the GSI criterion.
- At the former Plainwell Impoundment, the groundwater monitoring program was terminated early after PCBs were not detected in any of the 75 groundwater samples collected.
- At the 12<sup>th</sup> Street Landfill OU, the groundwater monitoring program is being reviewed after two years of monitoring, and to date, PCBs have not been detected in any groundwater samples.

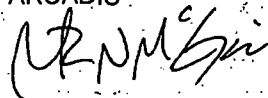
Taken together, these groundwater monitoring programs indicate that groundwater in the landfills and floodplain is not a source of PCBs to the River.

With this letter, we are reiterating our request for MDEQ's concurrence with the demonstration – carried out consistent with Part 201 – that PCBs in groundwater at the WB/A-Site OU present a *de minimis* effect on the Kalamazoo River.

We look forward to discussing this letter with you at the December 19, 2012 meeting at the WB/A-Site OU Project Office. If you have any questions regarding the data presented in this letter or in previous correspondence, please call me at 312.671.9233 or Garry Griffith at 734.735.0780, at your convenience.

Sincerely,

ARCADIS



Patrick N. McGuire  
Project Coordinator/Principal Environmental Engineer

Attachment

Copies:

John Bradley, MDEQ  
Anne Couture, MDEQ  
Daria Devantier, MDEQ  
Steven Hoin, MDEQ  
David Kline, MDEQ  
Michael Berkoff, USEPA  
Jeff Keiser, CH2M Hill  
Garry Griffith, Georgia-Pacific  
Michael Erickson, ARCADIS  
Daniel O'Neill, ARCADIS



**Attachment 1**

Willow Boulevard/  
A-Site Operable Unit:

Post-Closure Groundwater  
Monitoring Program



# Willow Boulevard/ A-Site Operable Unit:

## Post-Closure Groundwater Monitoring Program

December 2012





# Demonstration of *de minimis* effect on Kalamazoo River from Willow Boulevard / A-Site OU

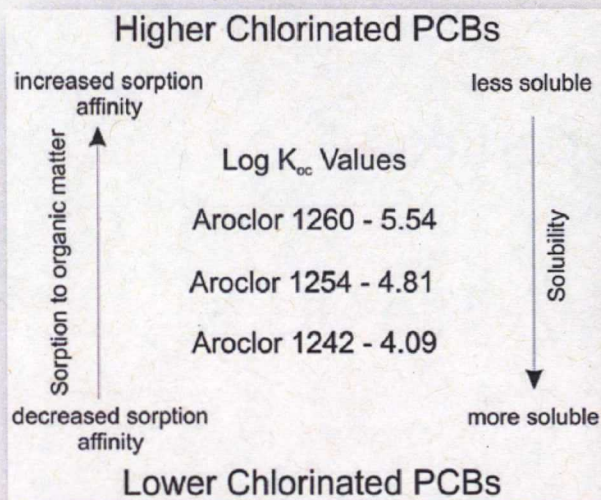


## ***De minimis* effect on Kalamazoo River**

- Key site-specific factors considered in assessing *de minimis* effect on Kalamazoo River from WB/A-Site OU include:
  - Chemical and physical properties of PCBs
  - Chemical and physical properties of paper residuals
  - Groundwater quality at WB/A-Site OU



# Chemical and Physical Properties of PCBs



- PCBs are hydrophobic, low miscibility in water (Chou and Griffin 1986)
- Decreasing solubility in water with increasing chlorination (Chou and Griffin 1986)
- Soluble in most organic solvents and oils (Erickson 1997)
- Adhere to particles, increasing adsorption with increasing chlorination (Chou and Griffin 1986)
- High organic carbon partition coefficient (K<sub>oc</sub>) values (Versar, Inc. 1998)
- Due to strong affinity to organic carbon, PCBs are quite immobile in soils and sediments (USEPA 1990)
- Generally do not leach to groundwater (ATSDR 2000; MDEQ 2011)

➤ ***PCBs in the Landfill OUs are not likely to move into groundwater or surface water***



## Chemical and Physical Properties of Paper Residuals

- Landfill OUs are “monofills” – primarily paper-making residuals with high clay content
  - High organic content (27 - 70% by weight)
  - Low hydraulic conductivity of residuals (Maltby and Eppstein 1996)
    - Laboratory studies: average of  $10^{-6}$  cm/s
    - Field studies: average of  $10^{-7}$  –  $10^{-8}$  cm/s
  - From 1990 to 2004 more than 29 industrial and municipal landfills were closed using residuals as hydraulic barrier layer (NCASI 2005)
- *PCBs in the Landfill OUs are not likely to move into groundwater or surface water*



# Modeled Potential PCB Flux in Groundwater

- Hydraulic conductivity of  $1.5 \times 10^{-3}$  cm/s ( $4.9 \times 10^{-5}$  ft/s)
- Hydraulic gradients ranging from 0.0029 to 0.010 ft/ft
- River flow of 575 cfs
- Average groundwater PCB concentration of 0.042 µg/L
- Upstream river PCB concentration of 0.001 µg/L

Parameter	Groundwater Discharge Area <sup>1</sup>		Hydraulic Conductivity (k) (ft/sec)	Hydraulic Gradient (i) (ft/ft) <sup>2</sup>	Groundwater Flow (Qp) (cfs)	Design Stream Flow (Qs) (cfs) <sup>3</sup>	Dilution Ratio (Qs/Qp)	Avg GW Conc. (ug/l) <sup>4</sup>	Upstream Conc. In River (ug/l)	Final Conc. In River (ug/l) <sup>5</sup>	Avg GW PCB Load (kg/yr)
	Length (ft)	Depth (ft)									
Min gradient	3,000	15	0.000049	0.0029	0.0064	575	89,537	0.042	0.001	0.0010005	<b>0.00024</b>
Avg observed gradient	3,000	15	0.000049	0.0040	0.0089	575	64,915	0.042	0.001	0.0010006	<b>0.00033</b>
Max observed gradient	3,000	15	0.000049	0.010	0.022	575	25,966	0.042	0.001	0.0010016	<b>0.00083</b>

## Notes

Worksheet derived from MDEQ Operational Memorandum RRD-5, Attachment 1 ([http://www.michigan.gov/documents/deq/deq-rrd-OpMemo\\_5\\_Form\\_286639\\_7.pdf](http://www.michigan.gov/documents/deq/deq-rrd-OpMemo_5_Form_286639_7.pdf)).

<sup>1</sup>Estimated groundwater discharge area to Kalamazoo River.

<sup>2</sup>Based on groundwater and surface water elevation monitoring, as presented in Figures 13A through 13C of RI/FFS report.

<sup>3</sup>Based on Comstock gage station data; lowest mean monthly discharge rate.

<sup>4</sup>Average calculated using 1/2 detection limit for those samples that were non-detect for PCBs. Groundwater samples from November-December 2000.

<sup>5</sup>Average surface water PCB concentration MDEQ 2011 LTM data at River Street.



# PCB Flux in Groundwater

- Average final instream PCB concentration is 0.0010006  $\mu\text{g/L}$ , comprised of:
  - 0.0010000  $\mu\text{g/L}$  from upstream
  - 0.0000006  $\mu\text{g/L}$  from groundwater
- Groundwater component is 2-3 orders of magnitude lower than Rule 57 surface water quality criteria of 0.00012  $\mu\text{g/L}$  (WV) and 0.000026  $\mu\text{g/L}$  (HCV), and 3 orders of magnitude lower than reporting limit of 0.001  $\mu\text{g/L}$
- Actual venting concentration likely to be less than this value due to conservative assumption that PCBs are present at one-half reporting limit for those samples that were non-detect for PCBs
- Estimated average annual groundwater PCB flux at WB/A-Site OU is 0.00033 kg/yr based on conservative assumptions

➤ ***PCB loading to River from WB/A OU groundwater is de minimis***



# Modeled PCB Flux from River Sediments to Surface Water

Dissolved phase PCB concentration computed using two-phase equilibrium partitioning equation:

$$\text{PCB Flux} = K_f * A * C_{\text{sed}} / (f_{\text{oc}} * K_{\text{oc}}) * 0.001, \text{ where}$$

- $K_f$  is sediment-water mass transfer coefficient (based on literature values)
- $A$  is sediment surface area (calculated as length \* width) adjacent to WB/A OU
- $C_{\text{sed}}$  is sediment PCB concentration (set at MDEQ detection limit for sediments)
- $f_{\text{oc}}$  is sediment fraction of organic carbon in sediment (based on measured values)
- $K_{\text{oc}}$  is sediment organic carbon partition coefficient (assumed to be 309,000 [log  $K_{\text{oc}}$  of 5.5])
- $C_{\text{pw}}$  is sediment porewater PCB concentration (calculated as  $C_{\text{sed}} / (f_{\text{oc}} * K_{\text{oc}})$ )

Sediment-Water Mass Transfer Coefficient (cm/day)	Sediment Surface Area			PCB <sub>sed</sub> (mg/kg) <sup>1</sup>	$f_{\text{oc}}$	$K_{\text{oc}}$ (L/kg) <sup>2</sup>	PCB <sub>pw</sub> (ug/L)	PCB Flux (kg/yr)
	Length (ft)	Width (ft)	Area (m <sup>2</sup> )					
5.0	3,000	175	48,774	0.33	0.019	309,000	0.056	0.050

## Notes

<sup>1</sup>MDEQ detection limit for PCBs in sediment.

<sup>2</sup>K<sub>oc</sub> for PCB from Table 39 of 1996 EPA Soil Screening Guidance.



# Comparison of PCB Flux in Sediments and Groundwater

- Flux of PCBs to surface water from sediment adjacent to WB/A OU is calculated to be 0.05 kg/yr (assuming PCB levels in sediments are at the MDEQ detection limit concentration for sediments), compared to 0.00033 kg/yr for groundwater
- Modeled average groundwater flux is <0.7% of flux from sediments
- ***PCB flux from groundwater to surface water is also de minimis relative to potential flux from sediment in River – even assuming sediments are at a very low level of contamination***



# Conclusions

- Contributions of groundwater to PCB entering the River are *de minimis*
  - The potential groundwater load is trivial compared to river PCB concentrations and transport
  - The potential groundwater PCB flux is trivial compared to sediment PCB flux – even if sediment PCB concentrations are assumed to be at the MDEQ's default detection limit
- *Potential for PCB impacts at GSI from the WB/A site groundwater is de minimis – even for pre-remedy conditions*
- *The remedy will only further reduce this potential*



# Monitoring Data and Observations for Willow Boulevard / A-Site OU and Other OUs



## Groundwater Monitoring Precedence at Other OUs

- 12<sup>th</sup> St Landfill OU and King Highway Landfill (KHL) OU, in particular, are very similar to WB/A OU:
  - Similar history
  - Large mass of PCB-containing residuals near the River
  - Similar levels of PCB in waste
  - Similar groundwater flow conditions
  - Similar groundwater quality
- *The data from these OUs and other monitoring at the Superfund Site inform the expectation and confidence of GSI protection*

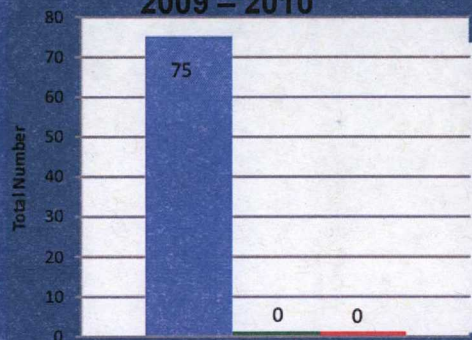


# Landfill OU Groundwater PCB Sampling Results

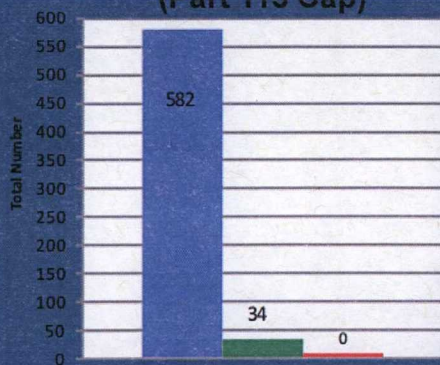
## LEGEND

- Total Samples
- Detects
- Detects > GSI Criterion

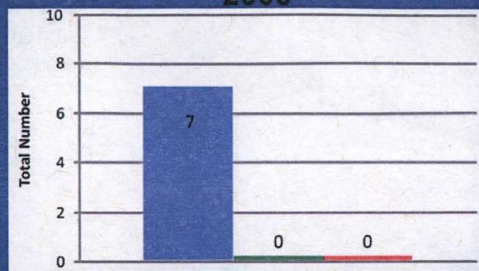
**Former Plainwell Impoundment –  
2009 – 2010**



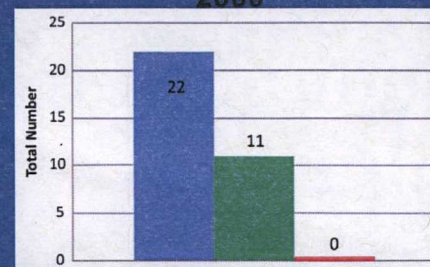
**King Highway Landfill OU  
2003 – 2011  
(Part 115 Cap)**



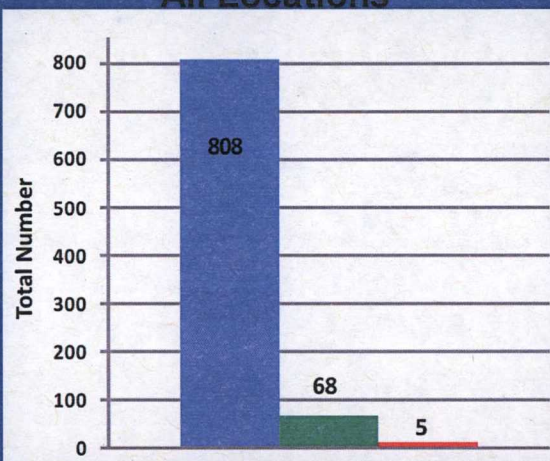
**Willow Boulevard Landfill – Not Closed  
2000**



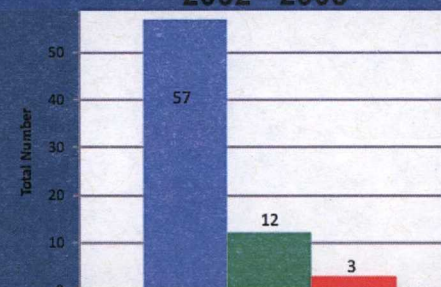
**A-Site Landfill – Not Closed  
2000**



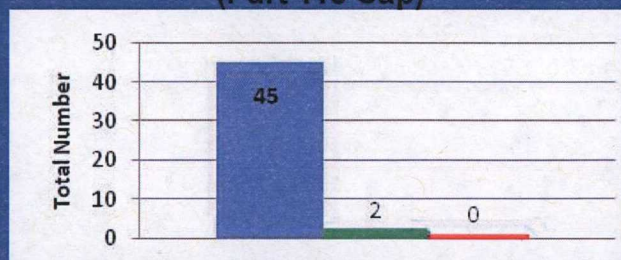
**All Locations**



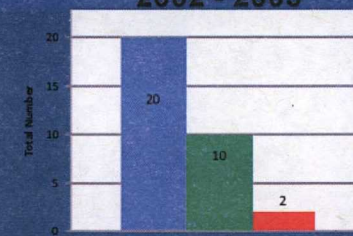
**Allied Paper, Inc. Landfill OU  
Groundwater – Not Closed  
2002 - 2003**



**12<sup>th</sup> Street Landfill OU  
2011 – 2012  
(Part 115 Cap)**



**Allied Paper, Inc. Landfill OU  
Seeps – Not Closed  
2002 - 2003**





## Reduction of Groundwater Monitoring Programs at other OUs

- **KHL OU:** scaled back after 8 years of data indicate no detections above GSI criterion – all non-PCB analyses eliminated, PCB reduced to annual
- **12<sup>th</sup> Street Landfill OU:** no upgradient monitoring after three quarters, program review after two years (results to date – no PCB detections)
- **Former Plainwell Impoundment:** program terminated early after no PCB detections
- *Groundwater monitoring programs are evolving based on adaptive management learnings – groundwater in landfills and floodplains is not a source of PCBs*